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ASPARAGUS PRODUCTION
IN CALIFORNIA

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G. C. HANNA¹

IMPORTANCE OF THE INDUSTRY

IN 1933, according to data from the United States Department of Agriculture, Bureau of Agricultural Economics, there were in this country 116,500 acres devoted to asparagus culture. Of this acreage over 65 per cent was located in California. New Jersey, South Carolina, Georgia, Illinois, and Pennsylvania follow in the order mentioned. Of the total, 60,830 acres were devoted to the production of market asparagus, and the other 55,670 primarily to asparagus for canning, most of which, however, is cut for market during the early part of the season.

The growing of asparagus for canning has, until recently, been confined to the Sacramento-San-Joaquin Delta of California, which still produces almost all the canned white asparagus. Within the past few years, however, Illinois, New Jersey, and South Carolina have developed a green-asparagus-canning industry. Although green asparagus has been canned in California since 1920, it was only a small percentage of the total pack until 1930. Since then it has gained in popularity, so that in 1934 it comprised about 40 per cent of the total asparagus canned.

CLIMATIC AND SOIL REQUIREMENTS

Some asparagus is grown in nearly all sections of the United States, though extensive cultivation is restricted to a few localities. California production is confined to the Sacramento-San-Joaquin, Imperial, and San Fernando valleys. For heaviest yields a rich soil 8 to 10 feet deep is needed—one retentive of moisture, yet open and porous enough to facilitate drainage. Early production depends upon a soil that warms readily. Most of the better-producing fields in the Delta region are found on a muck-sediment mixture, and this soil type is especially desirable in the production of white asparagus for canning. It warms rapidly in the spring and, being loose and friable, allows the spears to grow straight upward. It is less susceptible to wind erosion than the lighter peat and sandy soils. Clay soils warm too slowly, are difficult to manage, do not drain readily, and produce a high percentage of crooked spears.

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VARIETIES

California produces, at present, only three varieties of asparagus of commercial importance: Mary Washington, Palmetto, and Argenteuil. Most of the old fields are of Palmetto; but within the past few years the new beds have been planted largely with Mary Washington, which now

TABLE 1
ASPARAGUS CARLOT SHIPMENTS IN 1933*

State	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
Arizona.....	0	12	1	0	0	0	0	16	1	39
California.....	310	1,093	68	27	1	0	0	0	0	1,499
	120	378	43	12	0	0	0	0	0	553
	56	34	0	0	0	0	1	66	28	185
Georgia.....	18	83	3	0	0	0	0	0	0	104
Illinois.....	0	18	79	15	0	0	0	0	0	112
Maryland.....	0	0	7	1	0	0	0	0	0	8
	0	0	40	25	2	0	0	0	0	67
Nevada.....	1	0	0	0	0	0	0	0	0	1
Oregon.....	0	0	1	0	0	0	0	0	0	1
South Carolina.....	69	446	69	0	0	0	0	0	0	584
Washington.....	0	44	6	0	0	0	0	0	0	50
Total.....	573	2,118	317	80	3	0	1	82	29	3,203

* Data from the United States Department of Agriculture, Bureau of Agricultural Economics. Subject to revision.

TABLE 2
CARLOT SHIPMENTS OF ASPARAGUS 1926 TO 1933*

State	1926	1927	1928	1929	1930	1931	1932	1933	1934
Arizona.....	0	0	0	0	0	18	36	39	43
California.....	1,503	1,154	1,875	1,154	1,746	2,793	3,531	2,227	2,746
Delaware.....	0	0	0	1	3	17	0	0	0
Georgia.....	53	111	158	120	145	154	75	104	91
Illinois.....	144	158	213	146	142	146	76	112	72
Nevada.....	0	0	0	0	0	2	3	1	1
New Jersey.....	226	156	34	33	53	32	4	0	1
Oregon.....	11	8	7	31	21	8	7	1	0
South Carolina.....	364	447	463	507	551	590	474	584	492
Washington.....	111	93	127	107	105	67	88	50	103
Maryland.....	4	3	0	3	24	37	35	75	73
Others.....	3	2	0	0	0	0	0	0	7
Total.....	2,419	2,132	2,877	2,102	2,790	3,866	4,329	3,203	3,533

* Data from the United States Department of Agriculture, Bureau of Agricultural Economics. Subject to revision.

comprises about 65 per cent of the acreage. This latter variety is tighter-headed, earlier, and a little larger than Palmetto. On heavy soils, however, many large spears are rough and coarse, requiring heavy culling at the cannery. Many growers, therefore, now question the superiority of

Mary Washington over Palmetto, especially in the heavier soils of the Delta region. Argenteuil, though planted from time to time, appears now to be losing favor because of its tendency to produce pyramid-shaped spears; considerable weight is lost when the large butts are trimmed off at the cannery. Connover's Colossal, a light-green variety

TABLE 3
CARLOT SHIPMENTS IN CALIFORNIA*

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1923	0	0	83	247	79	49	0	0	0	0	0	0	458
1924	0	6	216	346	93	54	3	0	0	0	0	0	718
1925	0	10	524	567	109	67	1	0	0	0	0	0	1,278
1926	0	1	691	563	173	64	0	0	0	14	4	0	1,510
1927	0	0	188	636	204	118	1	0	0	6	1	0	1,154
1928	0	0	624	913	220	84	3	0	24	7	0	0	1,875
1929	0	0	203	613	202	88	6	0	0	36	6	0	1,154
1930	0	10	828	714	92	54	0	0	1	41	5	0	1,745
1931	0	35	1,338	1,044	189	57	1	0	6	91	32	4	2,793
1932	0	5	1,047	2,020	292	66	2	0	9	79	11	0	3,531
1933	0	0	486	1,505	111	39	0	0	1	66	28	0	2,237
1934	0	129	1,939	564	3	1	0	0	0	63	32	4	2,735

* Data from the United States Department of Agriculture, Bureau of Agricultural Economics. Subject to revision.

TABLE 4
CANNED PACK FOR CALIFORNIA*

Year	Cases	Year	Cases
1919	1,031,269	1927.....	2,189,570
1920	1,024,813	1928.....	2,337,950
1921	887,030	1929.....	2,672,637
1922	1,239,839	1930.....	2,663,191
1923	1,519,756	1931.....	1,747,499
1924	1,792,769	1932.....	1,313,231
1925	1,744,999	1933.....	2,134,943
1926	2,236,111	1934.....	1,914,000

* Data from the United States Department of Agriculture, Bureau of Agricultural Economics.

formerly used for canning in California, has almost entirely disappeared because of its lower yields and its susceptibility to rust.

SELECTING THE SEED

The selection of asparagus plants from which to harvest seed is very important. Perhaps no other cultivated crop of commercial significance has such a range of types within a variety. Individual plant-performance records at Davis show a wide variation between plants in earliness, yield, size of spears, tightness of head, color, and shape of spear. Some plants produce practically all culls; others very few. Some plants always start production early and continue to send up spears throughout the season,

whereas others start late and send up a spear only occasionally. Records at Davis show that one plant produced only one spear during the cutting seasons from 1930 to 1933, while a nearby plant produced over 30 pounds. Seeds selected from high-producing plants of the desirable types do not come true, but they should produce better plants than seeds selected at random from the field.

The seed plants should be selected from young beds before the crowns

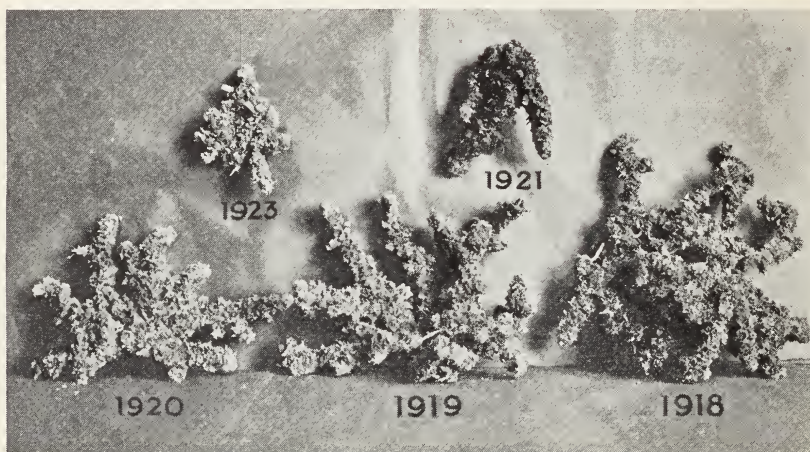


Fig. 1.—Five different ages of asparagus crowns, showing the growth made each year. Photographed July 25, 1924. Crowns set in the field in 1918, 1919, 1920, 1921, and 1923. (From Bul. 446.)

have grown together and lost their identity. There is a high correlation between the aboveground height of the first branch and the compactness of head. The higher the branching, the tighter the heads are during the cutting season. A fair index for judging the yield of a plant three to five years old is the amount of spread the crown has made as compared with the surrounding plants. The natural method of growth is to make an ever-widening circle (fig. 1). A plant that produces numerous spears spreads faster than one that produces only a few. Plants that show, in cross section, a high percentage of oblong to flat-shaped stalks will produce a high percentage of spears of this shape, which is objectionable.

Another index of the number and size of spears to be expected is the number and size of the stalks. Plants that produce many small stalks will produce many small spears; or a plant that produces a few large stalks will produce only a few large spears during the cutting season. Plants with rough or corrugated stalks should be avoided, for they will also produce this same type of spear. With this fact in mind, one should select seed from plants having numerous good-sized, smooth, and high-

branching stalks; the crowns should have a wide spread; and the fern should be compact and dense, with long cladophylls or needles.

PLANTING AND MANAGING THE NURSERY

Growing Versus Buying the Crowns.—Most growers prefer to grow their own crowns rather than buy them. There are several reasons for this:



Fig. 2.—Asparagus nursery. (From Bul. 446.)

(1) The grower has definite information about the seed. As stated elsewhere in this circular, the selection of good seed is a very important consideration. (2) It usually costs less to grow crowns than to buy them. (3) There is an opportunity to rogue out the poor crowns, and as stated previously, the proper time to do this is while the plants are still growing in the nursery. (4) There is usually less delay between digging the crowns and time of planting when the grower grows his own roots. Best results are obtained when the crowns are planted immediately after digging. In California the plants make a greater growth in one season than in other parts of the country. For this reason only one-year-old crowns are planted.

If crowns are bought, the buyer should specify that only well-developed one-year-old crowns will be accepted.

Seeding.—Up to the present time no really satisfactory machine for planting asparagus seed has been developed. In order to dig the crowns at a minimum of cost and root injury, one should space the plants so that they can be easily separated. Growers have several methods of sowing

the seed. One is to stagger the seed in furrows with bottoms about 6 inches wide in order to give the plants plenty of room to develop and yet produce a large number of plants per acre. Seeding is sometimes done by shaking a tomato can with holes in the bottom over the furrow. This method is unsatisfactory because an even stand cannot be obtained and weeding in the wide rows must be done by hand; at digging time, furthermore, the storage roots have become very much intertwined and difficult to separate. One of the most satisfactory methods yet developed is to use a small grain drill of the internal-run, force-feed type that plants one seed at a time and can be regulated to space the seed uniformly.

Rate of Seeding.—Growers tend to plant the seed too thickly. Asparagus seeds remain viable for several years and a high percentage of them germinate. To facilitate separation at digging time the plants should not be closer than 3 or 4 inches in the row. The rows should be at least 20 to 24 inches apart to permit cultivation between them. At this spacing 3 to 4 pounds of seed will plant 1 acre of nursery, whereas most growers use 8 to 12 pounds, and some as high as 20 pounds per acre. The heavier rates of seeding produce very small crowns, closely intertwined and therefore difficult to separate. The extra effort needed to pull these apart increases the cost of digging and the amount of injury. Blue molds readily enter the injured crowns and reduce the vitality or, in cases of severe injury, kill the crowns.

Time of Seeding.—In the Sacramento-San-Joaquin Delta, March and April are the best months to plant the nursery. In the Imperial Valley the work may be done earlier. Early planting insures larger crowns; but it also increases the amount of hand weeding to be done, because the seed germinates more slowly at lower temperatures. For this reason land as free as possible should be selected for the nursery site.

To hasten germination Borthwick² advises soaking the seed for 4 or 5 days at 86° Fahrenheit. When removed from the water, the seed is spread on a canvas and air-dried for a few minutes so that it will pass through the drill freely. Only a small quantity should be dried at a time, for the seed loses the benefit of soaking if it becomes too dry. In soaking, one must prevent the seed from sprouting before it is planted. Drying out of sprouted seed or breaking the sprouts will result in a poor stand. In planting after soaking, one must be careful to have abundant moisture in the soil.

Depth of Planting.—If the nursery is planted early, the seed should be placed 1 to 1½ inches deep in both peat and sediment soils, because at this depth the soil warms quickly. Later plantings should be made deeper

² Borthwick, H. A. Factors influencing the rate of germination of the seed of *Asparagus officinalis*. California Agr. Exp. Sta. Tech. Paper 18:1-17. 1925.

to help insure abundant moisture. At all times, care must be exercised to prevent drying out of the seed bed.

Thinning.—In order to secure a good stand some growers prefer to seed heavily and then to thin. This procedure is rather costly and difficult, especially where three or four seeds have been dropped in the same



Fig. 3.—The difference in size of these two plants results from differences in heredity. They grew side by side in a nursery with the plants spaced 6 inches apart in the row.

place. In thinning, the “eye” or small crown must be removed, or it will grow again.

Irrigating.—In the past few years growers have come to favor portable sprinkling systems for irrigating nurseries in the Delta region. Many believe that this method of watering keeps the soil packed down around the plants and tends to reduce the alkali injury until the plants are well established. Moist soils in the Delta are heavily charged with

alkali, and young asparagus seedlings are easily injured by excessive deposits of alkali in the upper soil surface.

As the large, fleshy storage roots will not elongate in dry soil, an adequate supply of available moisture should be present at all times to insure proper growth. According to Jones and Robbins³ water should not be



Fig. 4.—The same plants as in figure 3 but with the tops removed.

applied after the early part of September: forced growth after this time is a heavy drain on the plant.

Selecting the Crowns.—The crowns are graded after digging, when they are being separated. Those that are not too small or too severely injured are retained. Such grading has more merit when the plants are equally spaced in the nursery. When crowded the plants will be smaller than those spaced farther apart. Naturally, many small crowns are obtained that would have been much larger under proper growing conditions. Figure 3 shows the inherent differences between plants having equal environmental possibilities for development; these two plants grew side by side in a nursery, spaced 6 inches apart.

Better results can be secured by selecting the plants from the appearance of the top growth rather than the size of the roots; one is thus

³ Jones, H. A., and W. W. Robbins. The asparagus industry in California. California Agr. Sta. Bul. 446:1-105. 1928.

better able to judge the yielding potentialities. Because of variable soil and moisture conditions, the top growth will not be uniform over the nursery; and one must consider this fact when making the selection.

As stated previously, there is a wide variation in yield between plants. As shown by unpublished data from individual plant records at Davis and at the Ryer Island Field Station, the yield can be greatly increased by eliminating the plants in the lower range. The plant on the right of figure 4 has only one bud cluster, whereas that on the left has six. At digging time such a plant as the larger one would often be divided into five or six portions, each considered as a separate plant. Two or three portions would be considered too small to plant and would be discarded, but in reality these small portions are far superior to the plant on the right. Discarding the smaller portions of a large and vigorous crown reduces the value of crown selection at the time the roots are dug.

By late fall a large percentage of the plants have bloomed, and the sex may be determined by examining the blossom. Yield can be materially increased by planting only male plants. This system increases the cost of the roots, but the yields from such a bed more than offset the initial planting cost. Thus if the nursery is carefully rogued in October or November and all poor plants are destroyed, a materially increased yield may be expected over the plants from an unrogued nursery.

Digging the Crowns.—In the Delta region the tops are usually cut with a mower, raked, and burned, and the crowns dug in December and January. As a rule the crowns are turned out with a moldboard plow and pulled from the soil with a potato hook. Some growers use a U-shaped nursery plow that cuts the roots and lifts the plants so that they can be pulled out. Lately some have been using a potato digger that lifts the roots and shakes them free of most of the soil. This last method has proved rather satisfactory provided the plowing is not too shallow; it facilitates the separation of the crowns and reduces much of the mechanical injury that occurs in the first two methods. Wounding should be reduced to a minimum, for decay organisms readily enter injured roots and reduce the plant's vitality.

Some growers, in order to facilitate planting, prune all roots to about 4 or 5 inches in length. This practice cannot be recommended: it reduces the stored food, injures the roots, and, if good growing conditions do not prevail at planting, makes many of the plants fail to grow.

ESTABLISHING THE PLANTATION

Preparing the Soil.—As a rule very little financial return is realized during the first three years after planting. The condition of the land, therefore, should be such that the necessary cultural operations are re-

duced to a minimum. Lands contaminated with morning-glory (*Convolvulus arvensis* L.), nut grass or nut sedge (*Cyperus rotundus* L.), and water grass (*Echinochloa crusgali* Beauv.) are particularly difficult to keep clean. Where these weeds are prevalent the cost of hoeing and plowing may be materially increased. If possible the land should be flooded during the previous summer and fall, then thoroughly disked to kill

TABLE 5
AVERAGE WEIGHT OF SPEARS IN GRAMS, AT DAVIS; ROWS SPACED
7.5 FEET APART*

Spacing, inches	1925	1926	1927	1928	1929	1930	1931
12	18.73	22.80	26.32	27.93	29.33	26.43	27.03
18	20.48	26.07	29.65	32.02	32.28	28.62	28.27
30	21.67	26.91	29.25	30.53	31.27	27.62	26.90
36	21.46	27.33	29.86	31.30	32.97	28.68	28.54

* From: Jones, H. A. Spacing studies with asparagus. California Agr. Exp. Sta. Bul. 525:5. Table 2. 1932.

TABLE 6
PERFORMANCE* OF ASPARAGUS PLANTS SPACED DIFFERENT DISTANCES IN THE ROW
AT RYER ISLAND; ROWS SPACED 7.5 FEET APART

Year	Spacing	Number of spears per acre	Average weight per spear	Yield per acre
	<i>inches</i>		<i>grams</i>	<i>pounds</i>
1932	12	20,358	40.35	1,851
	18	16,312	41.21	1,483
	24	14,475	41.14	1,314
	30	11,104	40.75	1,009
	36	9,807	42.20	901
1933	12	37,702	45.97	3,802
	18	29,793	45.64	2,983
	24	27,268	44.49	2,661
	30	23,589	40.17	2,285
	36	20,116	40.62	1,792
1934	12	61,794	40.9	5,354
	18	55,354	39.7	4,665
	24	50,290	41.3	4,316
	30	43,840	39.8	3,722
	36	41,041	37.7	3,320

* Data computed on the average of five replications.

germinating seeds. Another thorough disking just before furrowing will kill the winter weeds.

Where subirrigation is practiced, the land should be as level as possible so that the water applications will be uniform through the field. Where the land is to be watered by surface irrigation, a slight fall of 2 to 4 inches for every 100 feet of row is needed for best results.

Time of Planting.—In the Sacramento–San-Joaquin Delta, planting is done at any time during the winter provided the soil is not too wet. January and February are perhaps the best months to plant. Usually environmental conditions permit the transplanted crowns to start growth in the latter part of February. Often if the crowns are planted long before growing conditions are good, considerable decay occurs on

TABLE 7
AVERAGE YIELD OF SPEARS IN POUNDS PER ACRE AT DAVIS;
ROWS SPACED 7.5 FEET APART*

Spacing, inches	1925	1926	1927	1928	1929	1930	1931	Total
12.....	492	2,711	4,361	5,508	6,506	7,424	10,646	37,648
18.....	437	2,670	4,368	5,643	6,524	7,437	10,362	37,441
30.....	317	1,864	3,414	4,595	5,611	6,502	9,063	31,466
36.....	259	1,735	3,085	4,255	5,308	6,023	8,761	29,426

* From: Jones, H. A. Spacing studies with asparagus. California Agr. Exp. Sta. Bul. 525:7 Table 5. 1932.

TABLE 8
AVERAGE NUMBER OF SPEARS PER PLANT AT DAVIS;
ROWS SPACED 7.5 FEET APART*

Spacing, inches	1925	1926	1927	1928	1929	1930	1931
12	2.09	9.43	13.16	15.66	17.62	22.30	31.28
18	2.57	11.95	17.75	21.23	24.36	31.31	44.16
30	2.90	14.49	23.18	29.89	35.63	46.75	66.92
36	2.82	14.88	24.23	31.88	37.76	49.25	70.89

* From: Jones, H. A. Spacing studies with asparagus. California Agr. Exp. Sta. Bul. 525:4. Table 1. 1932.

TABLE 9
NUMBER OF CROWNS REQUIRED TO PLANT AN ACRE FOR DIFFERENT SPACINGS

Distance between plants in the row, in inches	Distance between rows					
	4 feet	5 feet	6 feet	7 feet	8 feet	9 feet
12.....	10,890	8,712	7,260	6,223	5,080	5,445
15.....	8,712	6,969	5,808	4,978	4,620	4,356
18.....	7,260	5,808	4,840	4,148	3,872	3,630
24.....	5,445	4,356	3,630	3,111	2,904	2,722
30.....	4,356	3,485	2,904	2,489	2,310	2,178
36.....	3,630	2,904	2,420	2,074	1,936	1,815

the injured portions of the fleshy roots and rhizomes. If this decay advances too far, many crowns die, and a poor stand is obtained. Dipping or dusting the crowns to prevent decay has not been practical, nor has any other suitable preventive been worked out for this crop.

In the Imperial Valley the field may be planted any time during the winter, for there is very little interference from rain.

Distances Between Rows.—The distance between the rows will depend upon whether the spears are to be harvested white or green. If white is to be cut, the distances between rows should permit a ridge of soil to be made over the row without plowing too deeply for it between the rows.



Fig. 5.—One method of furrowing, preparatory to planting crowns.
The furrows are 8 to 12 inches deep. (From Bul. 446.)

The standard distance for such beds is $7\frac{1}{2}$ to 8 feet and should not be closer than 7 feet.

Fields on which only green asparagus is to be harvested can be planted closer—just how close without crowding is not yet known, because no data are available. There are a few small plantings of 4-foot widths in the Delta and Imperial Valley, but not old enough to give conclusive data. In planting the narrower distances, one should probably leave every seventh row unplanted for a roadway.

Spacing in the Row.—Within the past few years the distance between plants in the row has received considerable attention.

The data in table 5 show a slight decrease in average weight per spear from the 18 to 12-inch spacings, although this decrease is of little commercial importance. At all spacings the average weight per spear increased progressively up to the fifth year; after that came a decline.

Three years' harvesting data on Ryer Island (table 6) show no consistent difference in average weight per spear in spacings of 12 to 36 inches in the row. There is, however, a significant and progressive de-

crease in the yield per acre from 12 to 36-inch spacings. The yield for seven years on 12 to 36-inch spacings at Davis is shown in table 7. Here no significant difference is found between 12 and 18-inch spacings, but both are superior to farther spacings. Although the average number of spears per crown increases (table 8), this increase fails to compensate for the decreased number of crowns per acre.



Fig. 6.—Hauling asparagus crowns to the field. (From Bul. 446.)

In view of these data, there appears to be little choice between 12 and 18-inch spacings at Davis. Under Ryer Island conditions, the 12-inch spacing is up to the present time definitely superior, although the beds are too young to warrant any definite conclusions regarding future performance.

The number of crowns needed to plant an acre, using different spacings, is shown in table 9.

Plowing the Furrows.—The furrows are made with a double mold-board plow having extension wings. For large plantings two or three plows are fastened to a crossbeam and pulled by a tractor (fig. 5). The number of furrows made at one time should correspond to the number of rows to be cultivated at the same time. That is, if two furrows are made simultaneously, either single or two-row equipment should be used for cultivating. Wheel plows give better results than walking plows; they involve less side movement and make straighter rows. When

the rows are less than 7 feet apart, the soil will roll from one furrow into the next. When the rows are 4 feet apart, a fairly satisfactory method is to plant alternate rows first and the others later.

Planting.—The crowns are hauled to the field and placed in large piles (fig. 6) which should be spaced to eliminate, for the droppers, as much walking as possible. Planting is done by hand; about 2 acres is an



Fig. 7.—Dropping the crowns in the trenches. The man in the foreground carries a sack that holds the crowns. (From Bul. 446.)

average day's work where the rows are 8 feet apart. From 100 to 150 crowns are carried in burlap bags slung over the shoulders (fig. 7). They are dropped in the furrows with the buds pointing up. The spacing is usually estimated, being checked occasionally to insure uniformity.

Depth of Planting.—The depth of planting depends on the soil type. In sandy loam or peat soils, plantings should be deeper than on heavier soils. In the Delta on the light peat soils much of the top soil is lost by wind erosion during the cutting season. If plantings are made too shallow on these soils, the crowns are soon exposed. The usual depth in the Delta is 8 to 14 inches, 10 inches being the most common. Ten years' data at Davis on a silt-loam soil show an annual decrease of 1,041 pounds per acre when crowns were planted 12 inches deep as compared with an 8-inch depth. A three-year trial at Ryer Island showed no difference in production between 12 and 8-inch depths; but there was a reduction in yield when the crowns were planted 4 inches deep. At Davis and Ryer Island the 12-inch depth showed a decrease in average number of spears per plant as compared with 8-inch depth, but an increase in average size of spear.

Covering the Crowns.—Immediately after planting, the crowns are covered to a depth of 2 to 3 inches by means of a cultivator that pulls the soil from the sides of the furrow. Freeze injury can be prevented by covering the crowns the same day they are planted.

CARING FOR THE ESTABLISHED PLANTATION

The First Year.—Cultivation the first year consists of filling the furrows and keeping down the weeds. Many weeds in the row may be killed when small by covering them with soil as the furrows are filled. If the land is foul with weeds, several hoeings may be necessary.

The field should be kept well irrigated the first year. In years of light



Fig. 8.—Irrigating asparagus plots at Davis shortly after the crowns were set. (From Bul. 525.)

rainfall, or where the planting has been done after the rainy season, an irrigation soon after planting may be desirable. If the water is run down the rows, the soil is firmed around the crowns, and growth is hastened (fig. 8). The fleshy roots elongate in moist soil only. As the stored food supply in the crown, when planted, is very limited, the plant must become well established as soon as possible. Good care of the bed the first year is particularly important.

The tops are cut, raked, and burned after having been killed by the frost. As peat land will burn readily, the tops should not be burned on these soils unless there is sufficient moisture to prevent ground fires.

The Second Year.—Usually during the winter the land is thoroughly disked and left level. Since the stubble disintegrates readily, it does not interfere with harvesting. In California the practice is to cut the field 3 or 4 weeks or until the frost hazard is over, unless there was a poor fern growth the first year. Only green asparagus is cut. After cutting is stopped, the tops are allowed to grow. It is a general practice to cultivate deeply between the rows, and some growers subsoil to a depth of 12 to 18

inches in order to loosen the soil and allow water percolation. According to investigations on Ryer Island, however, deep cultivation or sub-soiling reduces the yield the following year. All reserve food for the following year's crop is stored in the fleshy roots during the summer and fall, and any cultivation practices that tend to destroy the roots will decrease the yield.



Fig. 9.—Harvesting is being changed from green to white. The ridges have been disked down and are being rebuilt higher.

After the Second Year.—The third year the field may be cut 8 to 10 weeks; in subsequent years, throughout the regular cutting season. In the fall, after frost has killed the tops, they are cut with a mower, raked, and burned. On peat soils the tops are not burned until after the first rains, for the dry peat soil will burn and kill the crowns. After the tops are disposed of, the fields are disked, and a low ridge of soil is thrown over the rows to facilitate decomposition of the stubble. After the fourth or fifth year, care is necessary in order not to cut the crowns as they approach the surface. Any destruction of the buds results in a decreased yield.

Harvesting usually starts in February or March, according to the season. Green asparagus is usually harvested until about April 1, when the canneries open.

For green asparagus only a low ridge is necessary. Older beds require higher and wider ridges—high enough to prevent touching the crown with the knife when cutting just below the ground.

For white asparagus the ridges are made high enough so that the spears can grow 8 or 9 inches below ground without being cut too close

to the crown. When cutting is changed from green to white, the ridge is disked down to kill the weeds and loosen the soil (fig. 9). This soil should be well pulverized before being put on the ridge (fig. 11), and a float dragged behind the ridger helps to pack and pulverize still further. (fig. 10). A cloddy ridge allows the light to filter in, and the spears become green before they show above the top of the soil. In addition, the



Fig. 10.—A board float attached behind the disks. (From Bul. 446.)

spears are liable to be more crooked when they are forced to grow around large clods.

For white asparagus production, the ridges are rebuilt every 18 to 21 days throughout the season, as they gradually become torn down by wind and cutting. After the cutting season the ridges are partially disked down and then flattened by means of a large weighted wooden beam. Throughout the summer, cultivation is practiced only to keep down the weeds.

In the Delta most asparagus fields are watered by subirrigation. Usually one or two irrigations are applied during the cutting season, and one or two during the summer. On heavy soils that do not subirrigate easily, surface irrigation is applied by furrows between the rows, usually one furrow every other row. Some growers on the lighter soils have begun to surface-irrigate in an attempt to leach the alkali out of the upper soil surface. In the Imperial and San Fernando valleys only surface irrigation is practiced. The water should penetrate to a depth of at least 8 to 10 feet.

Recently the practice of winter flooding has become somewhat general on the older beds in the Delta region. Levees are made around the field,

which is flooded to an average depth of 6 to 12 inches for a period of 4 to 6 weeks. Usually a few rows are left with the tops uncut next to the levee to check wave action. They are further protected by a lining of



Fig. 11.—Pulverizing the soil between the rows.

densely matted fern. In January or early February, according to the climatic conditions, the water is drained off, and the fields are allowed to dry. As soon as possible the centers are worked, and a small ridge is made over the row.

TABLE 10
PERFORMANCE OF FLOODED ASPARAGUS BEDS; MARY WASHINGTON VARIETY,
DELTA REGION*

Plot	1931 season		1932 season	
	Cut until	Yield per acre	Cut until	Yield per acre
		<i>pounds</i>		<i>pounds</i>
A	April 20.....	2,182	June 15.....	6,384
B	May 1.....	3,236	June 15.....	6,825
C	June 1.....	4,937	June 15.....	5,937
D	June 15.....	5,635	June 15.....	5,867
E	July 1.....	6,389	June 15.....	5,119

* From: Hanna, G. C. The effect of the duration of cutting season on asparagus that has been flooded. Proceedings of the American Society for Horticultural Science 29:466-467. Table I. 1932.

Fields flooded during the winter start to produce from 10 to 14 days earlier than nonflooded fields. In Arizona, Working⁴ found that growth started at 59° Fahrenheit when an abundance of moisture was present but that plants remained dormant at 63° when the soil was barely moist.

⁴ Working, E. B. Physical and chemical factors in the growth of asparagus. Arizona Agr. Exp. Sta. Tech. Bul. 5:85-124. 1924.

Many growers believe that flooding shortens the life of the bed. Table 10 shows the performance of a seven-year-old flooded bed of Mary Washington on the Egbert Tract on the western side of the Sacramento-San-Joaquin Delta cut for different lengths of time. The field was flooded 4 weeks in December, 1930.

In 1931 the quality of the asparagus fell off rapidly in plots cut after June 1. In 1932 the quality was also poorer on those plots cut longer than June 1, 1931. The data are not considered sufficient to determine the length of cutting after flooding, but probably the beds should not be cut later than June 1 under these conditions. There is apparently no harmful effect in flooding; therefore, the deleterious effect must come from cutting too long after flooding. Flooding in connection with good drainage may be very beneficial on subirrigated soils with a high salt content; it tends to leach the alkali out of the upper soil surface.

FERTILIZATION

In fertilizer trials at Ryer Island, virgin and replanted asparagus peat-sediment soils have failed to respond to any treatment regardless of kind, rate, or time of application. Some growers on peat land claim beneficial results from 200 pounds of calcium nitrate per acre, applied after harvest. In the Imperial Valley a 4-10-10 mixture is used and applications of manure are made to a limited extent during the winter. In the San Fernando Valley 100 to 150 pounds of sulfate of ammonia is applied immediately after the cutting season, supplemented by 6 to 10 tons of barnyard manure.

LIFE OF PLANTATION, AND REPLANTING

Life of Plantation.—The average profitable life of an asparagus plantation in the Delta region is from ten to fifteen years. On the lighter peat soils the beds decline very rapidly after the eighth year, whereas on the heavier muck soils this rapid decline does not begin until about the twelfth year, provided the beds have not been overcut or otherwise abused.

Replanting.—Just how soon old asparagus land can be replanted is a much-debated question. On Ryer Island replanting between the old rows immediately after plowing out the old bed gives about a 50 per cent normal yield. Probably replanting should not be done before seven to ten years after removal of the crowns; no data are available on the best crops to grow in the intervening period. Deep plowing or subsoiling will help destroy the old asparagus roots, which remain alive for several years after the crowns are destroyed.

HARVESTING ASPARAGUS FOR THE MARKET

In the early part of the season the cutters go over the field every 2 or 3 days, according to the rate of growth. Later the beds are cut every day. In the San Fernando and Imperial valleys the fields are gone over twice daily during warm weather. When the asparagus is to be shipped to market, the spears are cut 10 to 12 inches in length with as much green



Fig. 12.—Cart used in hauling asparagus from the field to the washing shed.
(From Bul. 446.)

as can be secured along with a tight head. Usually the cutter does not cut according to the length of the green alone but also considers the compactness of the head. The higher the temperature, the closer to the ground the spears will begin to branch. Spears having heads that tend to open early, and therefore having a shorter length of green, are cut somewhat sooner than those that tend to open late.

Early in the season, when the yield is small, the cutters carry baskets or especially constructed carrying boxes, from which the spears are transferred to 50-pound lug boxes at the end of the row. Later in the season, when production is heavier, the spears from six rows are placed in small piles on the two center rows, commonly designated as a "sled row." The spears are hauled in a horse-drawn cart (fig. 12) directly to the packing shed. If the shed is at a shipping point, the spears are placed in lug boxes as they are picked up from the field, and are carried to the ends of the row. Trucks haul the lugs to the shipping shed.

SORTING, GRADING, AND PACKING

In California there are two types of pack: the loose pack and the bunch pack. The smaller grades are usually put in the loose pack, the spears of which are trimmed to 9 inches in length.

The Loose Pack.—After trimming, the spears are placed in a so-called “pyramid” crate (fig. 13), on the bottom and two sides of which



Fig. 13.—The manner of making the loose pack. (From Bul. 446.)

oiled or wax paper is placed. On the paper in the bottom is laid a layer of wet moss or some other absorbent matter. During packing, the crate rests on its side. To facilitate handling, a tin sheet having the dimensions of the bottom is placed on top of the moss. The butts are placed against the tin sheet; and when the crate is filled the tin is pulled out, leaving the butts on the water-soaked moss. The oiled paper is folded over the open side, and the side and top slats are nailed on. The crates are packed to give a good bulge so that if wilting occurs the pack will remain tight. Most markets in California prefer the loose pack.

The Bunched Pack.—Most market asparagus is sold bunched. All grading is done by hand. Usually four to six grades are made, on the basis of the diameter of spear.

Bunching.—The different grades of spears are tied in bunches of approximately $2\frac{1}{2}$ pounds. The spears are placed in a buncher (fig. 14),

squeezed together by means of a lever, and tied securely with $\frac{1}{4}$ -inch tape. Different-colored tapes are used to designate the different grades. If the spears are slightly wilted, a tighter pack can be obtained, for they later absorb water from the moss and regain their turgidity.

Trimming.—After being securely tied, the asparagus is removed from the buncher and trimmed to 9 inches in length with a large knife or a

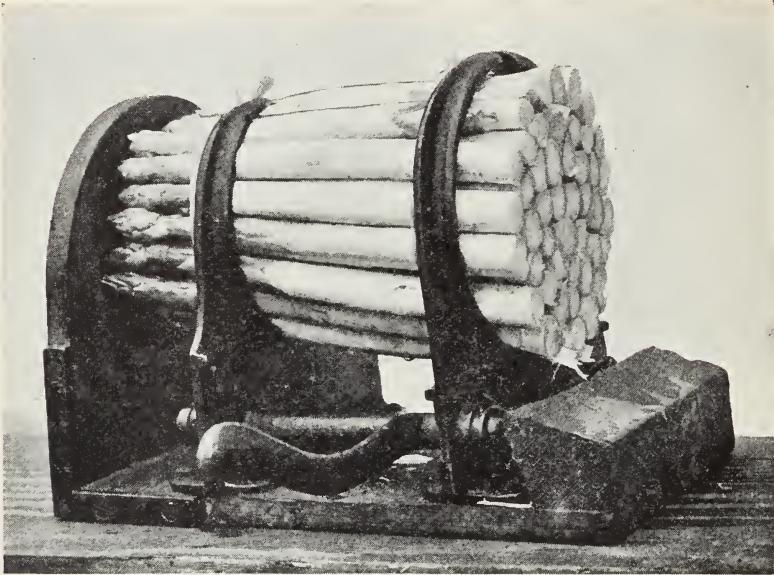


Fig. 14.—One type of asparagus buncher. Other types are on the market.
(From Bul. 446.)

circular power knife. The bunches are then placed upright with the butts in a pan filled with 3 to 4 inches of cold water. Here they remain until packed.

Packing.—The bunches are removed from the pans, wrapped in a parchment label, and placed in the crate with the butts resting on wet moss (fig. 16). The top and side boards are nailed on. Nearly all bunch asparagus is now shipped in a two-compartment standard-sized so-called “pyramid” crate.

Inspection.—Below are extracts from the Agricultural Code of California pertaining to shipment of fresh asparagus.

Sec. 810.5. Fresh asparagus shall not be wilted, or crushed (except such injuries as are necessarily caused in proper sorting or packing); stalks shall not have badly broken, badly spreading or badly seeded tips and shall be free from decay and from damage caused by dirt, disease, insects, mechanical injury or other causes. Stalks of asparagus, when bunch packed, shall not be badly crooked. “Damage” means any injury from the causes mentioned which materially affects the quality.

Not more than 10 per cent, by count, of the asparagus stalks in any one container or bulk lot may be below these requirements, but not to exceed one-half of this tolerance shall be allowed for any one cause. Asparagus which fails to meet these requirements only because of being "badly crooked" shall be considered as complying with this standard if the container in which it is packed is plainly marked on the outside of the end bearing other markings required by this section, in letters not less than one-half inch in height, with the word "crooks."

In view of differences in climatic and other natural conditions prevailing south and east of San Geronio Pass, which causes fresh asparagus grown in that area to be satisfactory in quality only if a large portion of the stalk is green or colored as compared to asparagus grown in the area north and west of the San Geronio Pass, stalks of asparagus produced in the area south and east of San Geronio Pass shall have not more than two inches of white on the butt, except that not more than 20 per cent of the stalks in any bunch, or when not packed in bunches, 20 per cent of

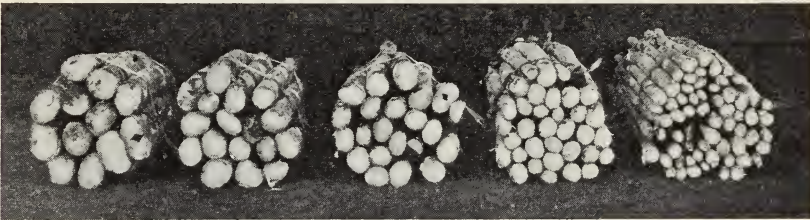


Fig. 15.—Five common grades of green asparagus: from left to right, Colossal, Extra Selected, Extra Fancy, Fancy, and Choice. (From Bul. 446.)

the stalks in any container, may have not to exceed two and one-half inches of white.

Bunches of asparagus classified according to the following designated size grades shall contain the number of stalks indicated in each classification and shall weigh not less than two pounds net when packed, except that bunches smaller than two pounds net when packed, with a proportionately less number of stalks per bunch, may be so classified if the container is conspicuously marked, on the outside of the end which bears any marks intended to describe the contents of such container, in letters not less than one-half inch in height, with the number of bunches and the minimum weight per bunch. Not less than twelve bunches of asparagus so classified may be packed in standard container number 51.

Colossal, not more than fourteen stalks to a bunch.

Jumbo, fifteen to twenty stalks to a bunch.

Extra select, twenty-one to twenty-eight stalks to a bunch.

Select, twenty-nine to forty-two stalks to a bunch.

Extra fancy, forty-three to sixty-seven stalks to a bunch.

Fancy, sixty-eight to one hundred stalks to a bunch.

"Crooks" when packed in bunches shall have no more than sixty-seven stalks to a bunch.

The number of stalks of asparagus packed in bunches shall not vary more than 10 per cent from the count of the grade classification as marked, except that 10 per cent, by count, of the bunches in any one container may exceed this tolerance.

All containers of asparagus packed in bunches shall bear upon them in plain sight and in plain letters on one outside end, the name of the person who first packed or authorized the packing of the asparagus, or the name under which such packer is

engaged in business, together with a sufficiently explicit address to permit ready location of such packer, the net weight, and in letters not less than one-half inch in height, the grade classification as herein established, except that crates of bunch packed asparagus which is badly crooked and so marked with the designation "crooks" need not bear any other grade classification; and in the case of bunches smaller than two pounds, with the number of bunches and minimum weight per bunch. When bunches of different grades are packed in one container, the markings on each container shall clearly show the number of bunches of each grade.

If 90 per cent, by count, of the stalks of asparagus in any container have less than 50 per cent of the length of the stalk white, the containers may be marked with the term "green."

Asparagus packed in bunches shall be in standard container number 51. Other size containers may be used if conspicuously marked on the outside end which bears any marks intended to describe the contents of such container, in letters not less than one-half of an inch in height with the words "irregular container."

Sec. 828. Container 51. The standard pyramid asparagus crate, maximum depth inside, eleven inches; length inside, eighteen inches; width at the bottom inside, eleven inches; maximum width at the top inside, ten inches, minimum width at the top inside, nine inches.⁵

LOADING, PRECOOLING, AND REFRIGERATION

The crates are loaded into the car immediately after packing. Usually they are stacked in tiers, four crates high, eight long; nine tiers are placed in one end and ten in the other, making 608 crates per car. Within the past few years precooling in northern California has gained rapidly, so that practically all cars are now precooled. In southern California all shipments are precooled. Bunker icing is practiced, with several re-icings during transit.

As the car is being loaded, the tiers are braced to hold them stationary. As soon as the load is complete the doors are closed, and the fans are turned on and run until the car temperature is about 40° Fahrenheit. The time usually required is 8 to 12 hours, according to the initial temperature. The all-green asparagus, which has a higher respiration rate than spears with white butts, takes longer to precool. Asparagus harvested and left in boxes in the field during the entire day will come into the packing shed warmer and will take longer to cool than asparagus harvested and hauled to the shed in the cool of the morning.

As Bisson, Jones, and Robbins⁶ have shown, there is a marked increase of lignified fibers and a decrease in percentage of sugar when asparagus is stored at 33° to 95° Fahrenheit. The higher the temperature at time

⁵ Bureau of Fruit and Vegetable Standardization. Extracts from Agricultural Code of California, p. 21-22, 32. Sacramento, 1933.

⁶ Bisson, C. S., H. A. Jones, and W. W. Robbins. Factors influencing the quality of fresh asparagus after it is harvested. California Agr. Exp. Sta. Bul. 410:1-28. 1926.

of storing, the more rapid the increase of crude fiber and the loss of sugar. Accompanying these changes there is also a loss of flavor and palatableness.

HARVESTING ASPARAGUS FOR THE CANNERY

The canneries usually open about April 1. By this time the daily yield is usually sufficient to bring the price down to that paid by the canneries. When white asparagus is to be delivered, the spears are cut just as they



Fig. 16.—Green asparagus, bunched and ready for shipment. (From Bul. 446.)

emerge through the soil. For green asparagus, the spears must have at least $3\frac{1}{2}$ inches of green. All cannery asparagus is trimmed to 7 inches before being delivered.

In the production of white asparagus the "grass" is brought from the field in "sled boxes" (fig. 12) to the wash sheds. On small plantations the wash shed is located in the field, usually one to every 100 to 150 acres. The asparagus is removed from the sled boxes and placed in a rack where it is trimmed to 7 inches in length (fig. 17). It is then washed, placed in 50-pound lug boxes, lidded, and hauled to the cannery.

On larger plantations a central wash shed is used, usually located on a slough. The sled boxes are left on loading platforms conveniently located in the field. Thence the boxes are hauled by trucks to the central wash shed, where the asparagus is trimmed by machine and washed by spraying water under high pressure on the spears. It is then crated and sent to the cannery by boat or truck.

INSECTS

As compared with most cultivated crops, asparagus in California is relatively free from insects and other pests. The asparagus beetle and the garden centipede are the two pests most apt to be troublesome.

The Common Asparagus Beetle.—The asparagus beetle, *Crioceris asparagi* L., is found in nearly all the asparagus-growing sections of the



Fig. 17.—Trimming asparagus in the field shed. (From Bul. 446.)

United States and is very common in Europe. It is about $\frac{1}{4}$ inch long, of a steel-blue color with a red thorax and with yellowish spots on the wings. The mature larvae are about $\frac{1}{3}$ inch long, soft and fleshy, much wrinkled, and smoky-grey. They drop to the ground and form small earth-covered cocoons.

The mature beetles attack both the spears and the stalks. Early in the spring the adults feed upon the growing spears, causing a distorted growth and lowering the sales value. After the cutting season both adults and larvae feed upon the top growth. Severe infestations often kill the tops, especially the upper portion. In California most of the damage is confined to young asparagus fields, which are cut not at all

or for a short time only, so that overwintering adults have a chance to deposit eggs on the young fern growth. The larvae appear in 3 to 8 days; the life cycle is completed in 3 to 4 weeks. There are many overlapping

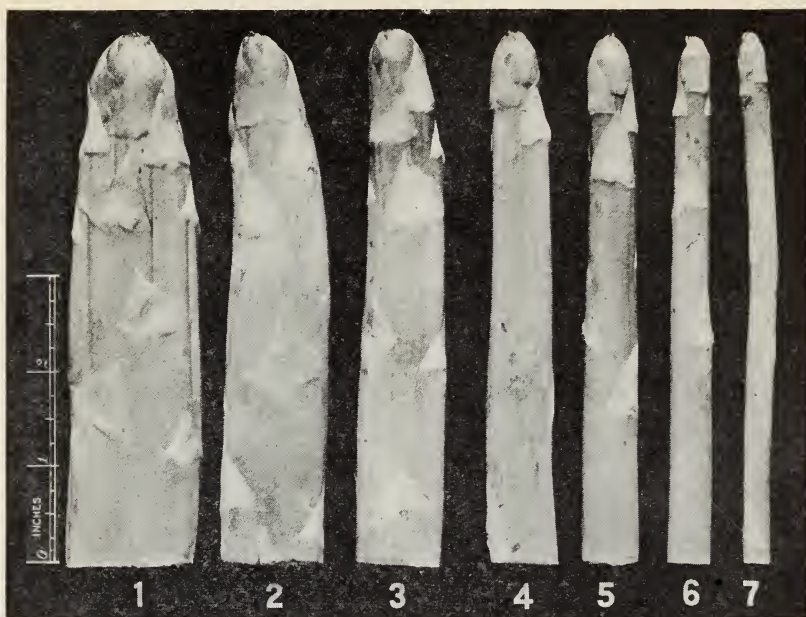


Fig. 18.—Grades of white asparagus for canning: 1, Giant; 2, Colossal; 3, Mammoth; 4, Large; 5, Medium; 6, Small; 7, Tiny. There are both “shorts” and “longs” of these seven grades. (From Bul. 446.)

generations. On young fields the population increases rapidly, and serious injury may result if control measures are not taken.

The asparagus beetle has many natural enemies. Several species of ladybird beetles feed upon the eggs, while numerous soldier bugs and dragonflies prey upon the larvae. In the Delta large flocks of blackbirds feed upon both larvae and adults.

A very satisfactory control can be obtained by dusting the fern tops with 1 part of powdered lead arsenate and 10 parts of air-slaked lime, applied early in the morning while the dew is still on the plant. Another satisfactory control is a spray consisting of 4 pounds of lead arsenate paste and 4 pounds of resin fish oil soap to 50 gallons of water.

The Garden Centipede.—The garden centipede, *Scutigera im-maculata* (Newport), is by far the most serious pest to the asparagus industry in California. Though small, these animals are very destructive when they occur in large numbers. When mature they are about $\frac{1}{4}$ inch long with delicate soft bodies (fig. 19). In feeding they make a large

number of small, round holes in the underground portion of the spear (fig. 21). Around these holes numerous hard fibers are formed, making the spear unfit for canning. When the centipedes are abundant in the soil, practically all the spears in the infested area will be injured. The top growth of such fields is reduced, and often the plants are killed.



Fig. 19. — Garden centipede; adult. (Ten times natural size.) (From Bul. 446.)



Fig. 20.—Eggs of the garden centipede. (Much enlarged.) (From Bul. 446.)

Usually only green asparagus is cut from badly infested fields; the green portion growing above the ground is not injured.

According to Wymore,⁷ where infestations are scattered throughout the field, flooding is the only practical means of control. A high levee is made around the field, and water a foot or more in depth is held on the field for 3 or 4 weeks during December and January. All high places should be completely covered, with no stubble left above the surface of the water. For very small infestations, a control may be obtained by using 2 ounces of carbon disulfide in holes 12 inches deep and 18 inches apart each way. Michelbacher⁸ found paradichlorobenzene effective when applied at 600 to 900 pounds per acre during warm weather. These chemicals are injurious to plants and would probably kill the crowns wherever they are applied, but on small infestations such a drastic method might be justified.

⁷ Wymore, F. H. The garden centipede, *Scutigera immaculata* (Newport), a pest of economic importance in the West. *Journal of Economic Entomology* 17:520-526. 1924.

⁸ Michelbacher, A. E. Chemical control of the garden centipede, *Scutigera immaculata*. *California Agr. Exp. Sta. Bul.* 548:1-19. 1932.

DISEASES

Asparagus Rust.—Asparagus rust, *Puccinia asparagi* D. C., first discovered in America in 1896, had spread to California by 1901. It is



Fig. 21.—Injury to asparagus by garden centipede. (From Bul. 446.)

readily recognized by brown, rusty spots on the stalks and branches of the plant. In severe infestations the whole field takes on a brown, rusty color. As this disease is prevalent only where summer rains or dews are encountered, it does little damage in the interior valleys, although in some years the rust has been rather severe. Smith,⁹ working in California, obtained good control from 25 to 30 pounds per acre of finely ground sulfur, applied as a dust about 3 weeks after the cutting season and



Fig. 22.—A view of flooding for the control of the garden centipede. The field to the right of the levee is thoroughly covered, whereas the ground about the building and at the end of the rows on the left now being flooded may prove a source for reinfestation of the whole field within a year or two. (From Bul. 518.)

followed by another application a month later. Fair control has been obtained by cutting, raking, and burning the tops in midsummer, the second top growth being relatively free of the disease.

The introduction of the rust-resistant Mary Washington and Martha Washington asparagus has reduced the rust hazard somewhat. These varieties, especially the former, are now generally planted in all sections of the state.

Another disease generally known as rust causes a rusty discoloration on white asparagus. It is due to soil organisms, principally *Rhizoctonia* species. In advanced cases there are sunken areas on the spears, but usually the spear is cut before the disease advances very far, so that only the rust-colored spots are present. This disease is most prevalent in fields that have a high water table or have recently received a heavy irrigation. To prevent this condition, the soil should be kept from becoming too moist above the crowns. Good drainage is essential at all times.

⁹ Smith, R. E. Asparagus and asparagus rust in California. California Agr. Exp. Sta. Bul. 165:1-99. 1905.